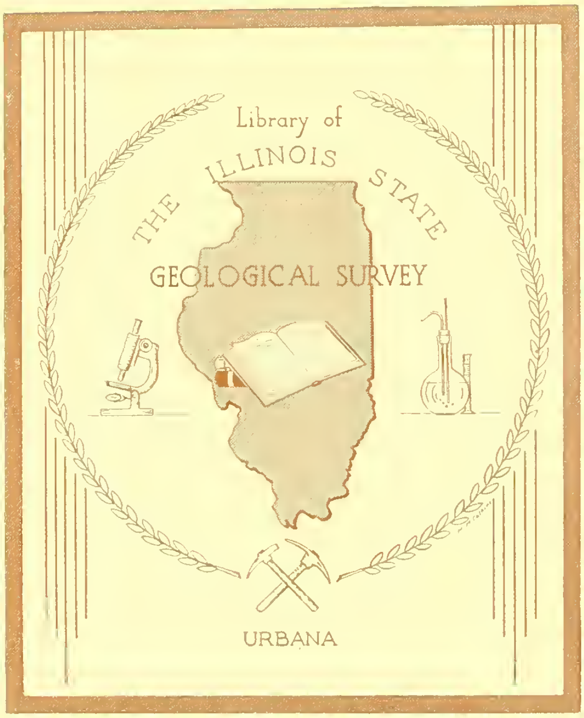
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SEPTEMBER 1970 • NUMBER 36

GEOLOGY FOR PLANNING AT CRESCENT CITY, ILLINOIS

Compiled by Robert E. Bergstrom

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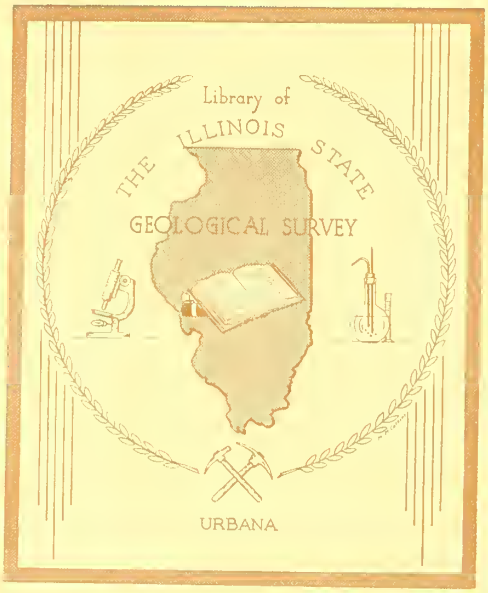

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GEOLOGY FOR PLANNING AT CRESCENT CITY, ILLINOIS

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INTRODUCTION

On the morning of June 21, 1970, the village of Crescent City, Illinois, about 75 miles south of Chicago, was heavily damaged by explosions and fires from 11 railroad tank cars containing propane in a train of the Toledo, Peoria, and Western Railroad that derailed within the village limits. The conflagration was violent; several propane tanks or parts of tanks were blown through the air for more than a block. Fifteen business places and 23 houses in the central portion of the village were destroyed. A large number of the remaining buildings in the village had windows broken or received other damage. Although there were no fatalities, some 70 people were injured, a large number of whom were firemen from nearby communities in Illinois and Indiana who responded to the call for help.

Crescent City, population 588, is located in Iroquois County at the junction of highways U. S. 24 and Illinois 49. In addition to the railroad, the village has a grain elevator and small business establishments and is situated just west of the crest of a natural gas-storage field of Northern Illinois Gas Company. There is a municipal water supply from relatively shallow wells in sand and gravel, but no sewerage system.

Following the catastrophe, the firm of Laz, Edwards, and Dankert, Architects and Planners, Champaign, Illinois, was engaged by the Illinois State Department of Local Government Affairs to assess the municipal conditions at Crescent City and prepare a plan for rebuilding the village. The firm requested

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the Illinois State Geological Survey to provide information on the geology and mineral resources of Crescent City and vicinity that would relate to planning and municipal services. This study, devoted to a six-mile square centered on Crescent City (fig. 1), was prepared in response to that request. Data from the files of the Geological Survey, supplemented by brief field studies of surficial deposits, ground-water conditions, factors relating to construction (engineering geology), and solid-waste disposal form the basis for the report.

This report is based mainly on studies of surficial geology by David L. Gross, engineering geology by Paul B. DuMontelle, ground-water conditions by Abdullatif Hamdan, and waste-disposal conditions by Frank B. Sherman.

GEOLOGY

Surficial Geology

Crescent City is situated on a relatively flat plain, which was a lake 14,000 years ago. The total relief of the area (figs. 1 and 2) is only a little more than 50 feet, ranging from 610 feet above sea level along Spring Creek in the northeast corner to 660 feet at the crests of sand dunes that rise above the lake plain in the south. Spring Creek and its tributaries drain most of the area. Spring Creek flows into the Iroquois River a half mile north of the northern boundary shown on the map (fig. 1).

Most of Illinois, including the Crescent City area, was glaciated several times by continental ice sheets. The deposits left by the glaciers in the Crescent City area reach a maximum thickness of about 200 feet. Only the most recent glacial deposits, those of the Wisconsinan glacier, are now exposed at the surface. Figure 1 shows the distribution of the surficial deposits to a depth of 20 feet in the area of Crescent City. The 20-foot depth was chosen because the deposits within this depth most directly influence the activities of man.

The explanation for figure 1 describes, from top to bottom, the five units left by Wisconsinan glaciers and gives the formal geologic names of the units (Willman and Frye, 1970). In various places in the study area, these units can be found within 20 feet of the land surface. The sequence of the surficial units, the variable thickness of all the glacial deposits, and the configuration of the bedrock surface below the glacial deposits are shown in cross sections A-A' and B-B' (fig. 2). The nature of these surficial units, which may determine their possible effect on various land uses, is further described below.

Unit 5, the lowest unit of the 20 feet of deposits considered in this study, is a glacial till that underlies the entire study area. Till is an unsorted rock debris that was deposited directly from the glacial ice; it consists of pebbles, cobbles, and sometimes even large boulders, imbedded in a matrix of clay, silt, and sand. The till of Unit 5 is a gray silty clay with abundant small (2 to 10 mm) pebbles. At Crescent City, the top of this till unit is about 10 feet below land surface, farther north it is 10 to more than 20 feet

EXPLANATION FOR FIGURE 1

Unit	Description
1	Loess (wind-blown silt), not shown on the map, 0-2 feet thick, incorporated in the modern soil; in the southeastern part of the area it may be interbedded in Unit 2. (Richland Loess)
2	Sand, yellow, fine grained; most of the material is in the form of sand dunes; generally less than 10 feet thick in the central part of the area and 10-20 feet thick in the southeastern corner of the area; it may contain some thin interbeds of loess; water often encountered within 5-10 feet of the surface. (Parkland Sand)
3	Sand (river-laid deposits), yellow, fine grained with some silt beds; more varied in texture than Unit 2; water often encountered within 5 feet of the surface. (Cahokia Alluvium)
4	Silt and clay (lake deposits), olive-colored at the surface grading downward to gray; silt or silty clay at the top grading downward to clay; up to 20 feet thick in the northwestern part of the area, but may be less than 10 feet thick in the southeastern part; lower 2 feet of the unit contains some silt and sand lenses; water often encountered within 5 feet of the surface. (Carmi Member, Equality Formation)
5	Till (ice-laid deposits), gray, silty clay with abundant small pebbles. (till of the Wedron Formation)

Older glacial deposits below

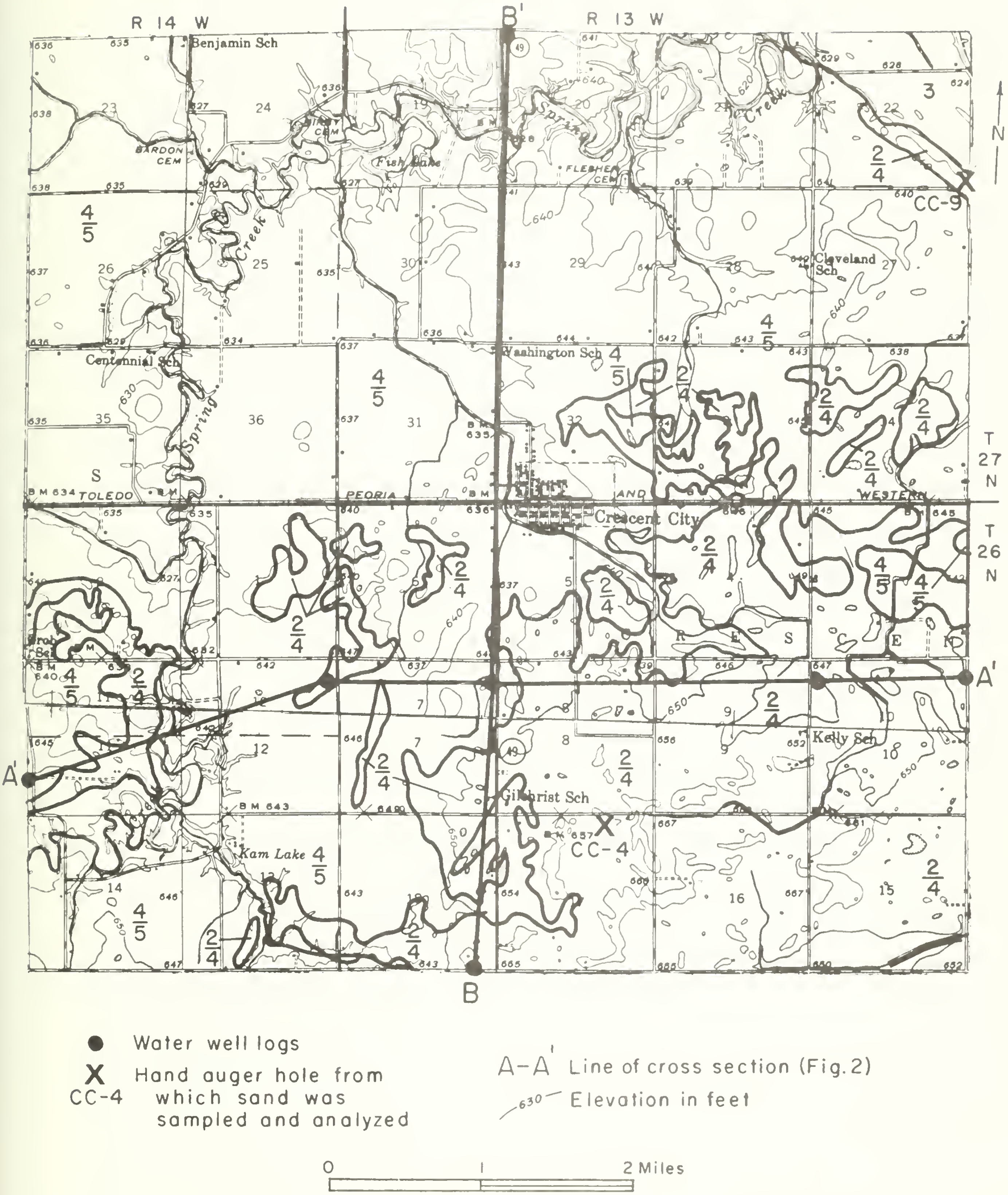
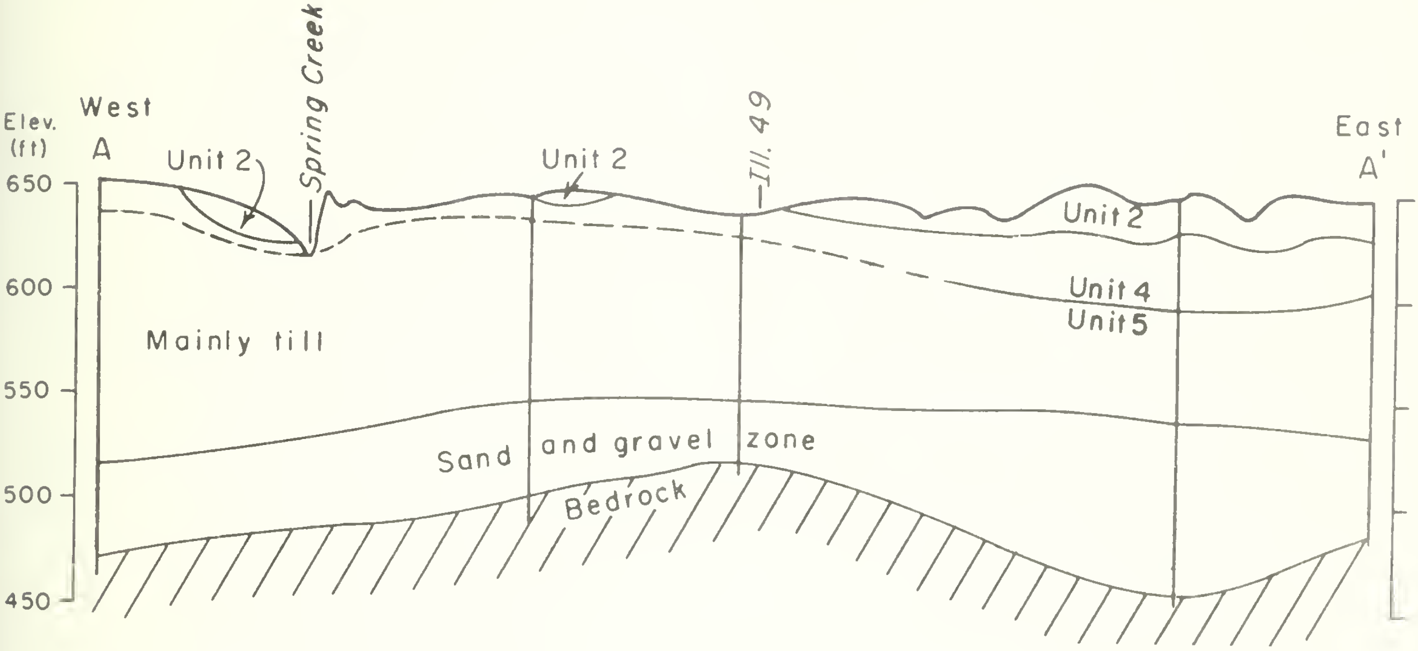


Fig. 1 - Surficial deposits mapped to a depth of 20 feet in the vicinity of Crescent City. The fraction-like numbers indicate units that are present within 20 feet of the surface in each area. For example, 4/5 shows that Unit 4 is present over Unit 5. Unit 1 overlies other units in the entire area but is not shown. (Mapping by David L. Gross.)



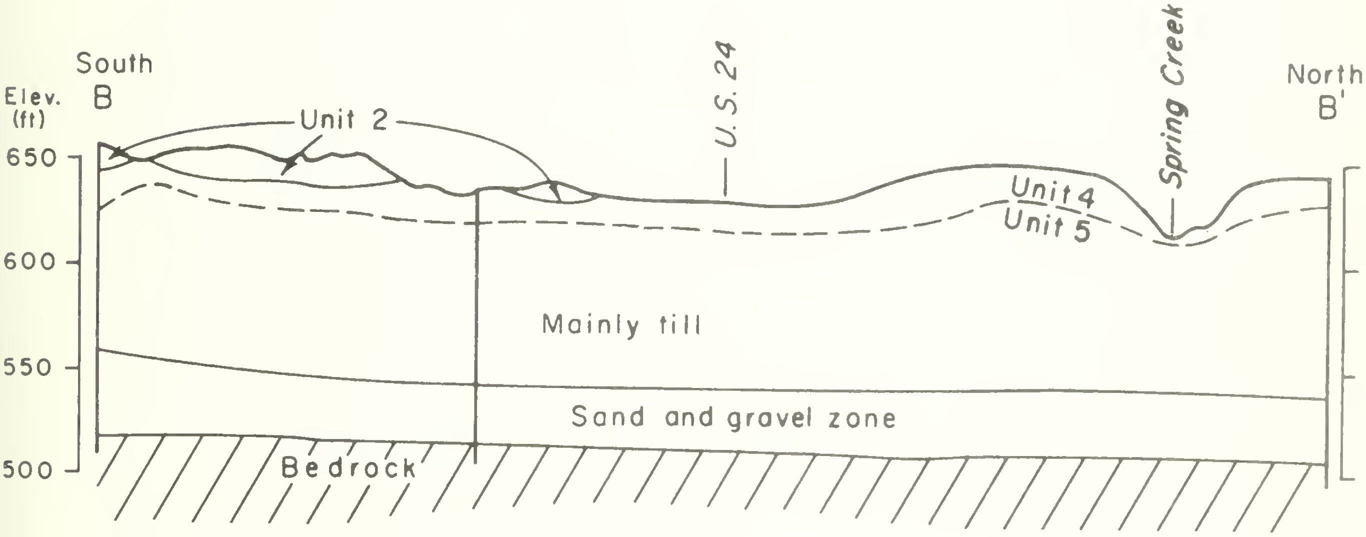


Fig. 2 - Generalized west-east (A-A') and south-north (B-B') cross sections showing the glacial deposits and the top of the bedrock. Units below Unit 5 have not been differentiated. The vertical lines are wells. Broken line between Units 4 and 5 indicates uncertainty of boundary. Surface loess (Unit 1) is not shown.

deep, and in the southeastern corner of the study area it is more than 20 feet from the surface. Throughout the area it occurs generally below the water table, and it is more compact than the overlying deposits.

In all but the northeastern corner of the study area, Unit 5 is known to be overlain by the silt and clay of Unit 4 (fig. 1). After the Wisconsinan glacier melted, a large lake known as Lake Watseka was formed. Unit 4 consists of the fine-grained sediments that were deposited in Lake Watseka. The unit is about 10 feet thick and is the surficial material at Crescent City; it is also the surficial material under all of the northwestern part of the study area, where it ranges up to 20 or more feet thick. It grades from an olive-colored clayey silt at the top to a gray clay at the base and is usually water saturated to within less than 5 feet of the surface.

Because it is fine-grained, it is relatively "tight" and does not yield water rapidly in drill holes or excavations. A hand auger hole drilled at the north edge of Crescent City, in the SW¼ SW¼ NW¼ sec. 32, T. 27 N., R. 13 W., illustrates the character of Units 4 and 5.

Depth (ft)	Description
0-9½	Clay (Unit 4), olive with faint 1-mm laminations, stiff, calcareous; modern soil developed in the upper 5 feet; water encountered at a depth of 6 feet
9½-14	Clay (Unit 4), as above, gray
14-15	Silt, gray, clayey, calcareous; trace of sand; a few small pebbles (mixed zone between Units 4 and 5)
15-16+	Till (Unit 5), gray, silty clay, calcareous; contains fragments of shale and abundant 2 to 5 mm pebbles; base of unit not penetrated

The sequence of deposits directly under Crescent City is similar to that described above, although the thicknesses of the various units may vary considerably. At the center and western edge of Crescent City, the upper 5 feet of Unit 4 may include some fine sand.

In the northeastern corner of the study area, several miles from Crescent City, Unit 4 is overlain by the river-laid sands and silts of Unit 3. These sediments were deposited in the valley of the Iroquois River and are quite variable, even within short distances. In this area water is encountered within 5 feet of the surface. Unit 3 was not studied in detail and its exact thickness is not known.

In the southeastern part of the study area, the silts and clays of Unit 4 are overlain by the fine-grained yellow dune sand of Unit 2. This sand

was blown from the large river floodplains onto the adjacent uplands. The sand dunes have long been stabilized. The areas of sand deposits close to Crescent City (fig. 1) are less than 10 feet thick, whereas those farther to the southeast may be up to 20 feet thick (fig. 2). The sands of Unit 2 are uniform in grain size and composition and contain only a few thin layers of silts. The upper part of the sand deposits is dry, the water table generally being more than 5 feet from the surface.

Where saturated, the sandy deposits yield water readily to drill holes and excavations. A hand auger hole drilled 1¼ miles west-southwest of Crescent City, in the SE¼ NE¼ NE¼ sec. 1, T. 26 N., R. 14 W., penetrated the following sequence of Units 2 and 4.

Depth (ft)	Description
0-4	Sand (Unit 2), yellow, fine grained; upper 1 foot silty; modern soil developed in the top
4-8	Silt (Unit 2), yellow, loose, calcareous; contains thin beds of fine-grained yellow sand
8-9+	Silt (Unit 4), olive, clayey, compact, calcareous; water encountered at a depth of 8 feet; base of unit not penetrated

The youngest deposit in this area is the thin blanket of loess, Unit 1, that covers most of the study area. Loess is silt-sized material derived from river floodplains and deposited by winds in the same manner as the sand dunes. Because it is so thin (0 to 2 feet), all of the loess has been incorporated in the modern soil profiles.

The map (fig. 1) and cross sections (fig. 2) were derived from a variety of sources, including field observations by geologists, logs of water wells and test holes drilled for the Crescent City gas-storage field, the soil map of Iroquois County (Wascher, Smith, and Odell, 1951), and the Gilman and Cissna Park 15-minute quadrangle topographic maps. The field work for this study included the drilling of 18 hand auger holes as much as 16 feet deep, studies of the various stream banks and roadcuts, and observations of the general topography of the area.

Ground-Water Geology

The Illinois Geological Survey has records of more than 80 water wells in the area around Crescent City (fig. 3). Many of the wells flow at the surface as a result of artesian pressure. More than 90 percent of these wells obtain water from permeable sand and gravel deposits of the glacial drift

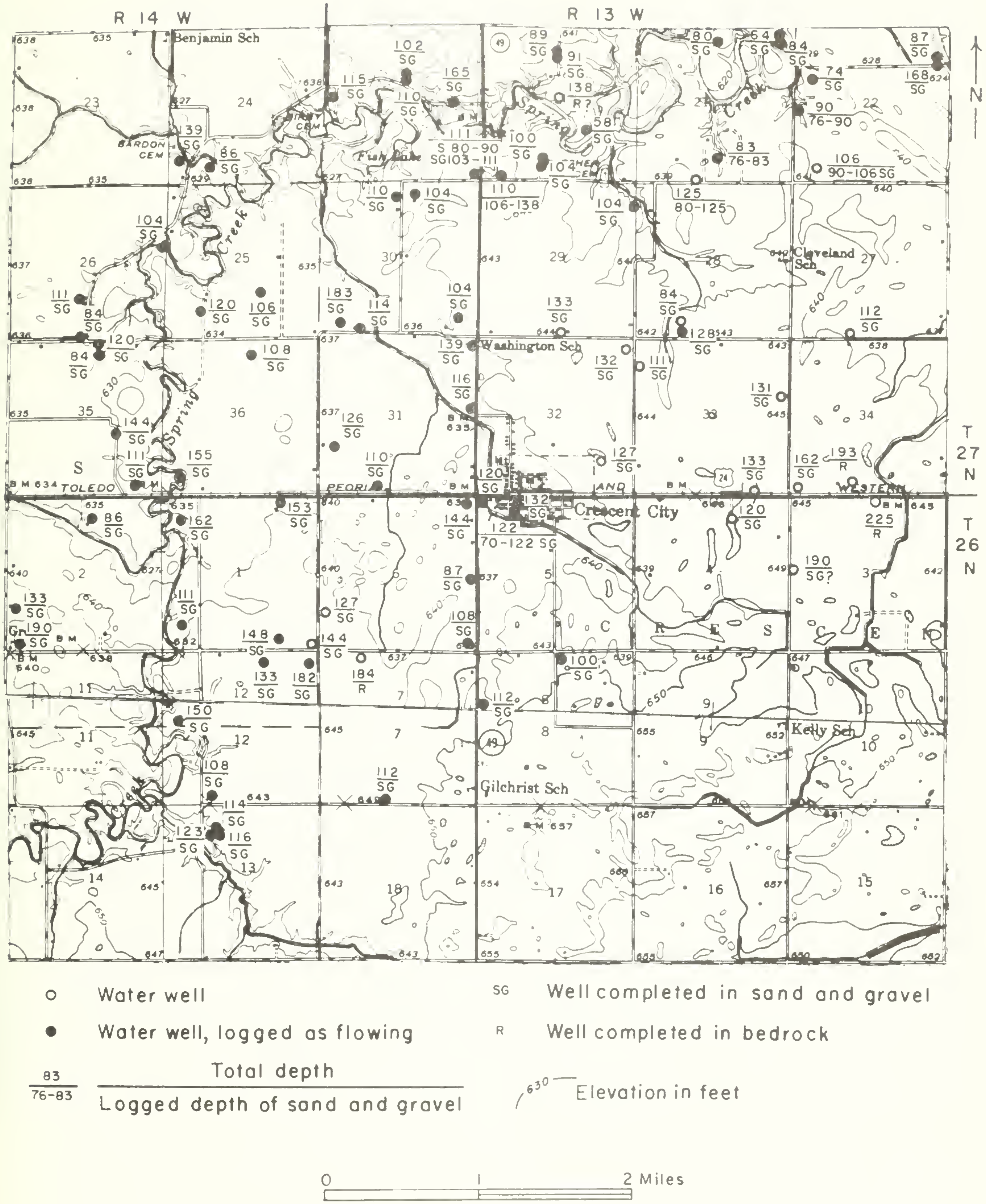


Fig. 3 - Wells with logs on file at the Illinois State Geological Survey.

within 150 feet of land surface (fig. 2). The water-yielding sand and gravel deposits (aquifers) range from 30 to 60 feet thick, and they are overlain by 50 to 90 feet of relatively impermeable clay and/or till deposits. Water from dug wells or sand points may be available from the sand-dune area southeast of Crescent City.

The municipal wells now in service at Crescent City are 122 and 132 feet deep. A log of the 122-foot well appears below:

Description	Thickness (ft)	Depth to base (ft)
Clay (Unit 4)	8	8
Sand (Unit 4)	2	10
Clay (Unit 5)	60	70
Sand grading into gravel	52	122 (total depth)

The Crescent City area is within a larger region (that includes much of Iroquois County) of artesian flow from the sand and gravel aquifers. Recent studies of this region show that around Crescent City the hydraulic head (the height to which water rises in a well) ranges from 620 to 650 feet above sea level. Flowing conditions exist wherever the hydraulic head in a well exceeds the land surface elevation, as is the case for much of the Crescent City area. The thick glacial tills and lake sediments overlying the sand and gravel aquifers are relatively impermeable, and, therefore, confine the water in the aquifers under pressure. The recharge, or intake, areas of the water are higher lands to the south in Iroquois County.

A few wells in the Crescent City area obtain water from the bedrock formations immediately below the drift. These formations are mainly limestones of Silurian and Devonian age (fig. 4). The wells are finished in the upper 75 feet of the bedrock, where the rock contains crevices and solution channels. Water is obtained from these openings. Deeper bedrock formations (fig. 5), such as those that are being used for the storage of natural gas nearby, contain water that is too highly mineralized for most purposes.

Water-bearing sand and gravel deposits of the glacial drift are present almost everywhere in the area, are generally more than 30 feet thick, are within 150 feet of land surface, and are capable of yielding enough water at many places for Crescent City's future water needs. Usually test drilling is necessary to determine the most favorable sites for municipal wells.

GENERAL CONSTRUCTION CONDITIONS

The physical character of the surficial deposits, the topography, and the subsurface water conditions are the main factors that affect construction and the selection of sites for highways, sewers, buildings, and homes.

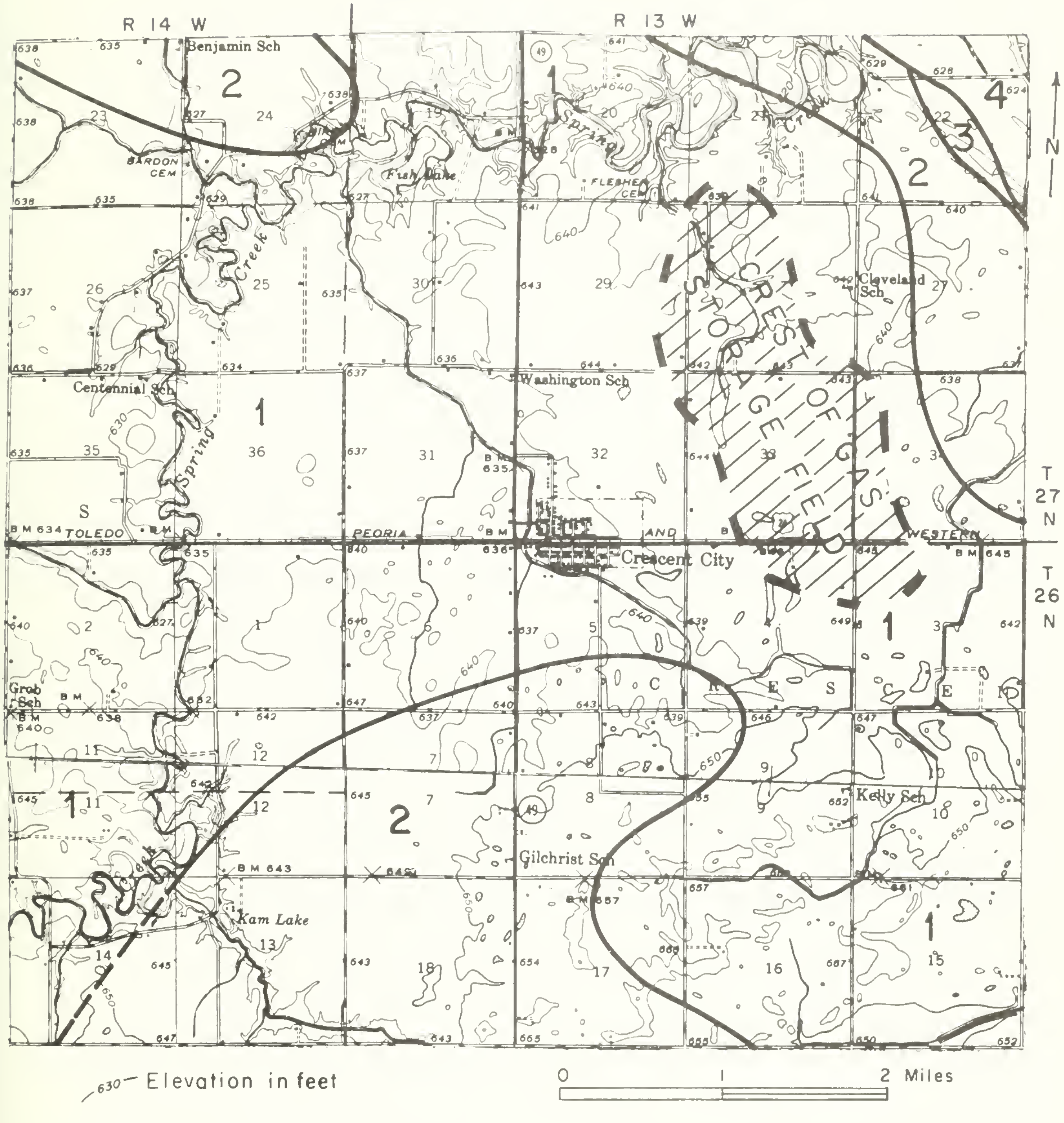


Fig. 4 - Geologic map of the bedrock surface, with area of gas storage field shown by diagonal pattern. 1 - Silurian rocks; 2 - Devonian rocks; 3 - Mississippian rocks; 4 - Pennsylvanian rocks. Sequence of rocks is shown in figure 5. (Map by Northern Illinois Gas Company.)

SYSTEM	GROUP OR FORMATION	DEPTH TO TOP (ft)	THICKNESS (ft)	ROCK TYPE	
Pleistocene Series			100-200	Glacial deposits—silt, clay, till, sand, and gravel	
PENNSYLVANIAN			0-60	Mainly shale	Limited distribution in area
MISSISSIPPIAN			0-60	Mainly shale	
DEVONIAN			0-100	Limestone	
SILURIAN			430	Dolomite	
ORDOVICIAN	Maquoketa	600	210	Mainly shale	
	Galena-Platteville	810	390	Dolomite	
	St. Peter	1200	180	Sandstone; gas-storage reservoir	
	Prairie du Chien	1380	450	Dolomite, sandstone	
CAMBRIAN	Eminence-Potosi	1830	500	Dolomite	
	Franconia	2350	130	Sandstone, dolomite, shale	
	Ironton-Galesville	2480	200	Sandstone	
	Eau Claire	2680	600	Siltstone, shale, dolomite	
	Mt. Simon	3280	200 penetrated	Sandstone, probable gas-storage reservoir	

Fig. 5 - Generalized column of rocks in the Crescent City area, as penetrated in Northern Illinois Gas Company testing program.

The nearly level or gently rolling topography of the Crescent City area eliminates the need for extensive cuts and fills in highway construction. However, in the flat areas underlain by Units 4 and 5, flooding may be a serious problem for homes and roads during heavy rainstorms. The floodplains of Spring Creek and the Iroquois River, and other areas with a history of flooding, should be avoided as sites for the construction of subdivisions. As mentioned previously in connection with the description of surficial deposits, a high water table is common in the vicinity of Crescent City and would affect construction of basements and operation of septic tank systems.

The primary geological factor influencing the selection of sites for construction is the physical character of the surficial deposits. The lowermost unit, the glacial till, whose full thickness was not determined during this investigation, is well consolidated and will provide sufficient strength for most large structures. The areas where till should be encountered at shallow depth are mapped as 4/5 in figure 1. The material in Unit 5 would also provide excellent borrow material.

Unit 4 is composed of lake sediments, ranging from a clay loam to a very fine sand, and the engineering characteristics vary accordingly. Trenches for sewer lines can easily be excavated in this material. Problems caused by the high water table may be avoided by planning excavation during periods of low water table (late summer or fall). Because of the high water table, construction of highways should generally include elevation of the roadbed. Materials in Unit 4 may be used for borrow purposes but may be difficult to handle because of the high plasticity of the clayey soils. Compaction and, more particularly, drying of fill material to optimum moisture content is important. Provision must be made for properly draining the fill materials. Some clay minerals have an affinity for water and tend to shrink when dry and swell when wet. Soils containing these clay minerals exert pressure that can cause damage to adjacent structures. However, two samples selected from clayey sediments (Unit 4) obtained from our auger holes and tested on a standard potential volume-change meter showed only marginal swell characteristics (2200 and 2400 pounds per square foot).

Some earth materials, depending on grain size and plasticity characteristics, are susceptible to frost action. The upward movement of water into these materials results in the accumulation of frost, which causes heaving of concrete slabs for roads and buildings. Frost susceptibility of the silty and fine sandy material of Unit 4 is medium to high (F_3 to F_4) (Linell, Hennion, and Lobaca, 1963) and can cause serious problems. The sediments of Unit 4 provide stable foundations for most small structures and excellent topsoil for slope planting.

The sand dunes, mainly in area 2/4 southeast of Crescent City, consist of very fine to medium sands. Excavation without dragline equipment is difficult in the dunes because of the high water table. Slopes must be protected from both wind and water erosion. Poorly drained areas are subject to the heaving action of frost. The sands are rated as fair topsoil material. A better use for this material may be as a source of borrow for blotting or blend sands. Blotting sands are used to soak up excess road oil. Blend sand is one of the components of asphalt sub-base and topping in road construction.

Two samples from the dune deposits (locations shown in fig. 1) meet the blend-sand requirements of the Illinois Division of Highways (1968), as shown below:

U. S. standard sieve (no.)	Passing required (%)	Sample CC-#9 (% passing the sieve)	Sample CC-#4 (% passing the sieve)
10	100	100	100
40	80-100	99.91	99.59
80	30- 90	72.39	66.58
200	0- 14	3.07	8.45

Unit 3 occurs on the floodplain of the Iroquois River. A high water table and possible flooding conditions are likely in this area. Susceptibility to frost heaving is high. The floodplain is a good source of borrow materials, if equipment suitable for high water-table conditions is used. Erosion is a serious problem, and slopes must be protected from both wind and water. Although the floodplain was not sampled for sources of blend sand, it is a likely area to investigate.

The foregoing section has summarized general construction conditions, possible problems, and the availability of construction materials, but evaluation of specific sites by an engineering geologist is necessary to determine particular conditions at each location. Additional information concerned with engineering properties of the soils of this region may be found in reports by Thornburn (1963) and Thornburn, Hagerty, and Liu (1968).

SOLID-WASTE DISPOSAL

Solid putrescible wastes are most commonly disposed of by burial in a sanitary landfill. Sanitary landfills in Illinois are regulated by the State Environmental Protection Agency. The location of the site and the proposed operational procedures must be approved before refuse can be disposed of at a landfill. Periodic inspections are made while a landfill is in operation to insure that the agency's requirements are being observed.

Enough precipitation occurs in Illinois to eventually saturate any landfill material. When saturation occurs, the rain water becomes highly mineralized as it leaches the refuse. This leachate, if allowed to migrate from the landfill, could contaminate ground and surface water. As a natural safeguard against contamination, landfills are usually permitted only in relatively impermeable, or slowly permeable, material that retards the movement of leachate. Daily and final cover material should be relatively impermeable to reduce the amount of precipitation infiltrating into the landfill. Ideally, refuse disposal below the water table is inadvisable; however, sites satisfying this criterion are extremely rare in northern Illinois. To protect underlying

aquifers, a minimum of 30 feet of relatively impermeable material is usually required between the base of a landfill and the shallowest aquifer. Construction of an impermeable clay liner is sometimes accepted as an adequate safeguard when the requisite thickness of natural material is absent.

Relatively impermeable materials at or near the land surface in the Crescent City area are clay, silt, and glacial till. The shallowest well reported in our records is more than 50 feet deep, though shallower wells, such as dug wells and sand points, may be present, particularly in the area southeast of Crescent City directly underlain by Unit 2. Available data suggest that a thickness of material sufficient to protect the aquifers from contamination by landfill leachate is present throughout the remainder of the area. The areas on the map of surficial deposits (fig. 1) where silt and clay (Unit 4) overlie till (Unit 5) are generally favorable for sanitary landfill operations. Usually studies of the specific site are necessary to determine whether or not that site is suitable for a sanitary landfill.

Those portions of the area where sand (Units 2 and 3) is known to be at or near the land surface, particularly southeast of Crescent City, (fig. 1) are less favorable for landfill operations. Because sand is highly permeable, it is not suitable for cover material and will not sufficiently retard the lateral movement of leachate. In such areas, contamination of shallow ground water and surface water might occur.

Noncombustible and nonputrescible wastes (e.g., demolition wastes, cinders, etc.) may be disposed of by open dumping at a sanitary landfill. These materials must be leveled and must finally be covered by earthen material, just as is required for a sanitary landfill. Landfills may be approved that lack the usual safeguards against pollution. if the stipulation is made that only noncombustible and nonputrescible wastes are deposited at the site.

CRESCENT CITY GAS-STORAGE FIELD

An important geologic feature between Crescent City and Watseka, Illinois, is an arch-shaped structure in the bedrock that is being used for the storage of natural gas. The structure was delineated by drilling in 1959, and injection of gas by the Northern Illinois Gas Company was begun in 1967. Withdrawal of gas will begin during the 1971-1972 heating season to help satisfy peak demands that cannot be met by the ordinary transmission of gas by pipeline from the gas fields of the Gulf Coast. Gas is injected into the storage reservoir when the flow of gas in the pipeline exceeds the demand.

The reservoir is in the St. Peter Sandstone, which is about 1200 feet below the surface (Buschbach and Bond, 1967). Along with the other bedrock of the region, the sandstone has been gently warped into an asymmetrical arch that trends northwest (fig. 4). The St. Peter is a porous sandstone that contains slightly brackish water, which is displaced as gas is injected into the rock to form a large bubble. The bubble of gas floats on the water at the crest of the arch and is kept from rising upward or migrating laterally by a dense 400-foot thick caprock, the dolomite of the Galena-Platteville Group. The sequence of rocks in the area is shown in figure 5.

The ultimate reservoir capacity of the St. Peter Sandstone in the structure is estimated to be 100 billion cubic feet of gas. Observation wells in the rocks overlying the sandstone will be used to monitor and collect any leakage gas. Overlying the dense dolomite caprock is the Maquoketa Shale Group, another dense formation that is 200 feet thick. At present, drilling exploration is under way at the Crescent City field to determine the feasibility of using the Mt. Simon Sandstone also for gas storage. The Mt. Simon occurs at a depth of about 3300 feet (fig. 5) and is used as a reservoir at many of the other gas-storage fields in Illinois.

Natural gas-storage projects must meet the requirements of the Federal Power Commission, the Illinois State Mining Board, the Illinois Environmental Protection Agency, and the Illinois Commerce Commission.

SUMMARY

No unusual or difficult geological limitations exist in the Crescent City area. The lake sediments in the northern and western halves of the region are generally fine-grained and tight, so that they do not yield water rapidly to excavations, even though the water table is relatively shallow. For the same reason, they do not accept fluids rapidly and are not well suited for the operation of septic tank fields. They should provide reasonably sound foundation materials and, along with the underlying tills, should afford protection to underlying aquifers where solid waste disposal is planned.

Ground water for present modest demands in the area has been generally available from sand and gravel aquifers at the base of the glacial drift. The ground water is under artesian pressure, and at many places wells flow naturally. The bedrock except for the uppermost formations is generally not favorable for development of ground-water supplies because much of the deeper water is too highly mineralized for most purposes.

An important geological feature of the area is the gas-storage structure between Crescent City and Watseka. In the absence of other near-by mineral resources, it is a significant economic asset. It is strategically placed for accommodating a part of the large Chicago suburban market for natural gas, and geological conditions and engineering safeguards combine to protect the public and the environment.

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